

Low-Cost Space Missions at the University of Toronto

By

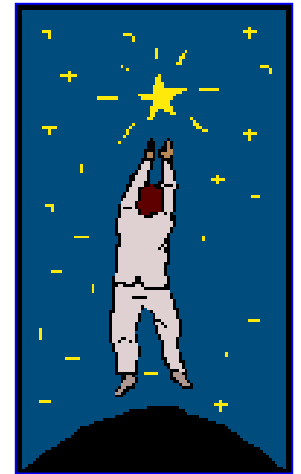
Robert E. Zee, PhD

Manager, Space Flight Laboratory

University of Toronto Institute for Aerospace Studies

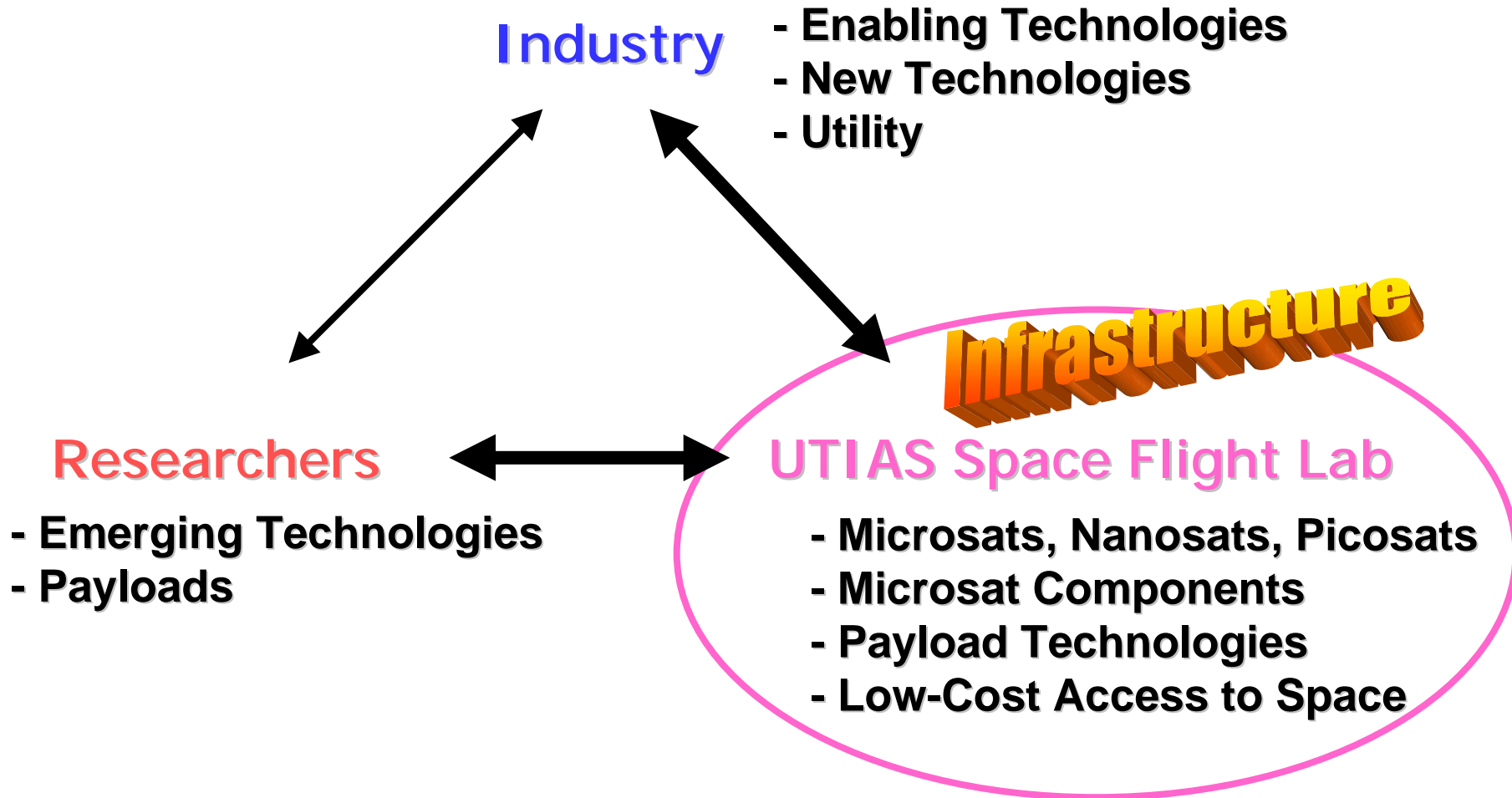
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University of Toronto Institute for Aerospace Studies Space Flight Laboratory



- Full-time staff trained by AMSAT.
- Expertise in electronics, computers, communications, structural and thermal design.
- Facilities to build, test, and qualify micro/nano/pico spacecraft.
- Student program: Masters and PhD theses, graduate project courses -- students work on real spacecraft.
- Objectives: Collaboration, innovation, education.

Collaboration



Microvariability and Oscillations of STars MicroSatellite Mission

- **Our First Mission**

- Canada's First Space Telescope
- Canadian Space Agency's first microsatellite
- Prime: Dynacon Enterprises Limited
- Subs: UTIAS/SFL and U. of British Columbia
- 900 km Dawn-Dusk Sun Synchronous Orbit
- Long-Duration Stellar Photometry (first time in space)
- Characterize Stars, Age of the Universe, Find ExtraSolar Planets

- **Established Facilities and Staff at UTIAS/SFL**

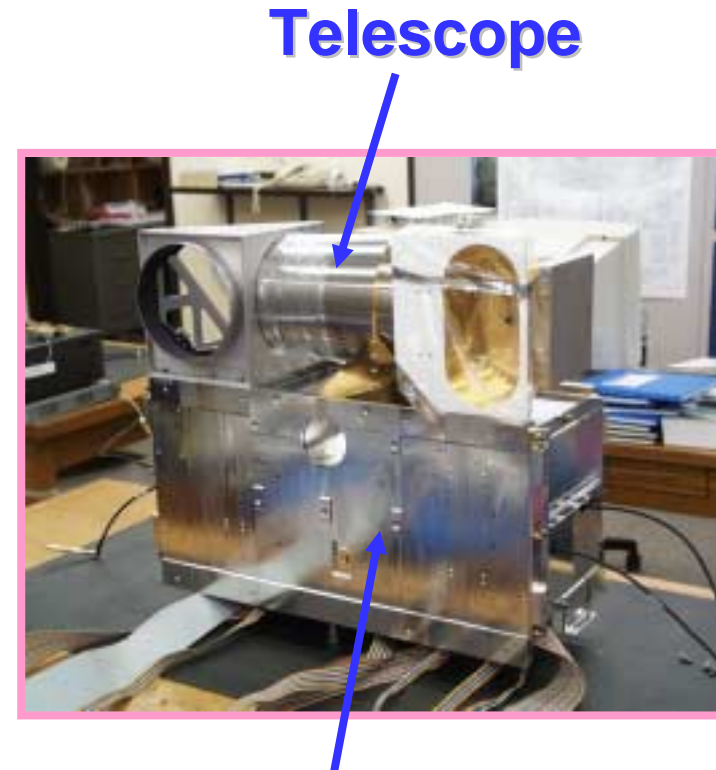
- Thermal + vacuum chambers, clean room, ground station, electronic assembly and test facilities.



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MOST MicroSatellite Mission

- **Bus Design, Assembly, Test**
 - 57 kg satellite, 60x60x30 cm approx.
 - Dynacon ACS: 25 arcsec pointing, 1 arcsec attitude determination
 - UTIAS/SFL developed structure, thermal, computer, communication subsystems
 - Involved in design, assembly, test, qualification, and operations
 - Currently finishing spacecraft integration and test.
- **Launch in Early 2003 (Eurockot)**

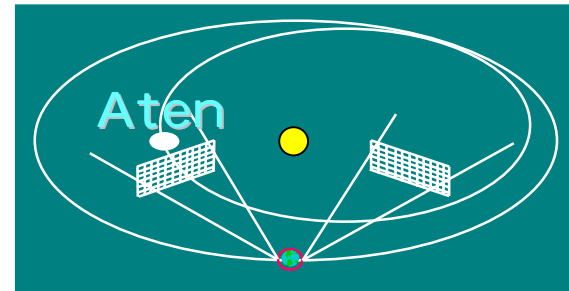


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Future MicroSat Missions

- Near-Earth Space Surveillance (NESS)

- Proposed Joint CSA/Defense Mission
- Track Near Earth Aten Asteroids (science) and Earth orbiting satellites (defense)

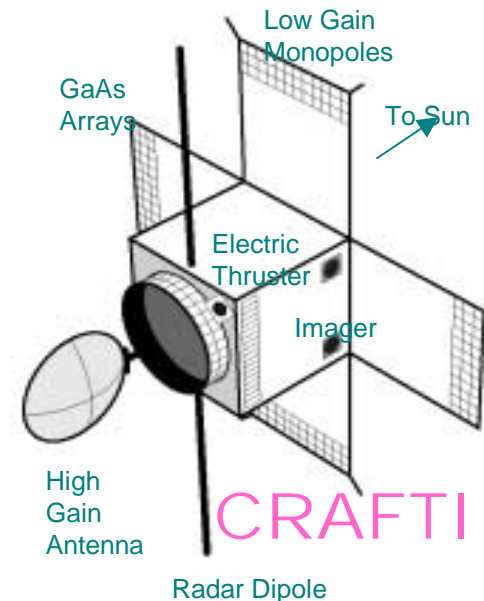


Toutatis



- Canadian Robotic Asteroid Flyby and Tentatively Impact (CRAFTI)

- Flyby and possibly impact asteroid Toutatis in 2008.
- Use low-cost microsatellite technology for exploration.
- Demonstrate simple/focused interplanetary mission for US\$13M including launch
- Use novel propulsion and communication systems

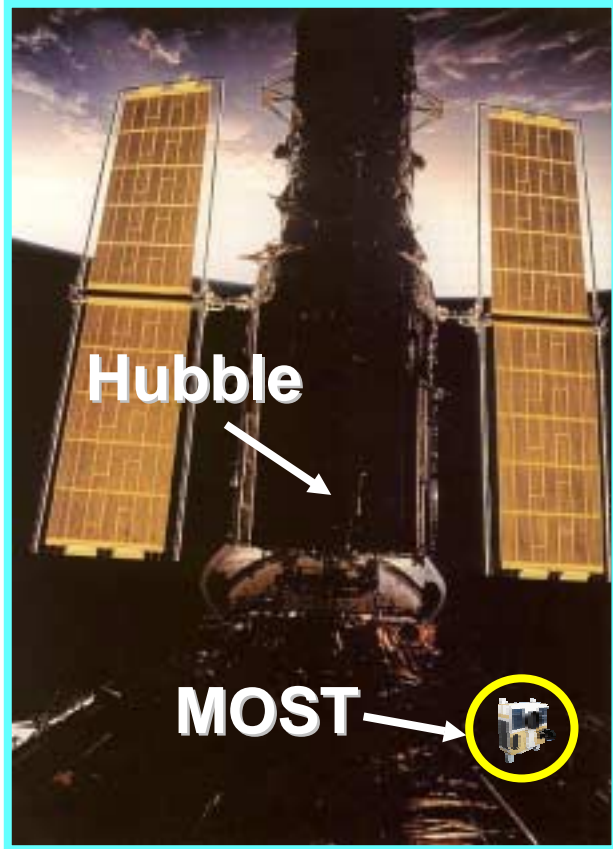


CRAFTI

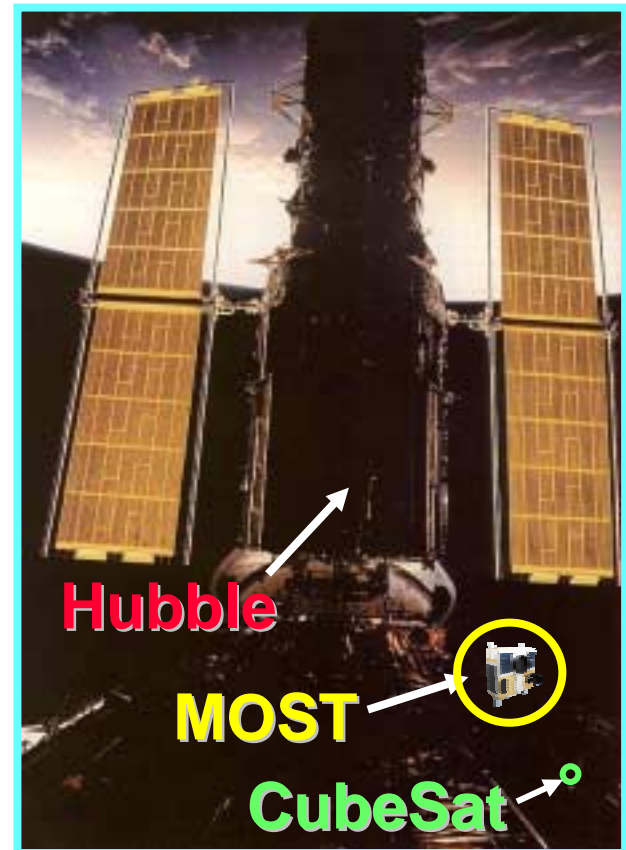
That's Nice, I Want More ...

- Microsatellite mission opportunities are relatively infrequent. Need to get to space faster for technology research.
- Student involvement in microsatellite missions limited to narrow topics and only a portion of the spacecraft development cycle.
- Need to create a stable program for students and space researchers.

... But How Much?



- Canadian Space Program 1/10 the size of NASA's
- Canadian dollar 2/3 the size of US dollar
- Canadians twice as cynical about space missions
- Canadian university funding for space very limited
- Need low-cost spacecraft, but no good if there are no low-cost launches
- Microsatellites are relatively big projects for universities
- Secondary payload slots are not always easy to find -- schedule is subject to delays, and costs are still big for universities
- Need regular launches that are cheap



- Stanford/CalPoly CubeSat program is an excellent way to get to space fast and at low-cost through collaboration.
- Supports low-cost space education and research.

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In a Perfect World ...



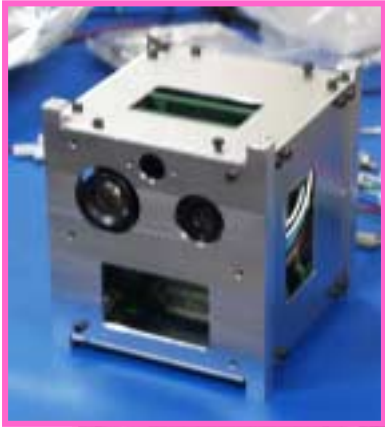
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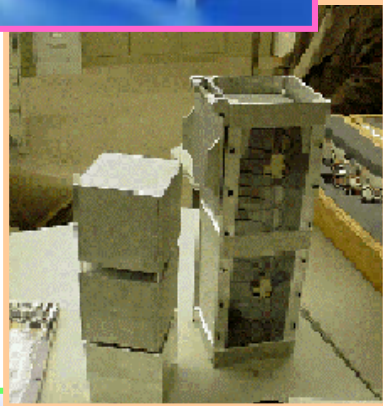
Minotaur

- Picosatellite launch costs need to be kept low, around US\$30K per kilogram.
- Launches must be regular and certain, at least once a year.
- Export control issues must be addressed early -- helps if an American vehicle is used.
- Helps if these are not mutually exclusive sets.
- NASA or DoD support of regular American picosat missions is essential to stabilize program.



CubeSats at U. of Toronto

- First mission is **CanX-1** (Canadian Advanced Nanospace eXperiment)
- Objectives:
 - Verify enabling technologies:
 - Imaging of Earth, Moon, stars using CMOS Imagers
 - Star/horizon tracking experiments
 - Demonstration of GPS from space
 - Magnetic attitude control
 - Flight-demonstration of high-performance ARM7 on-board computer (OBC)
 - Peak Power Tracking
 - Provide mission lifetime (one year) telemetry for solar cells and magnetometer
 - Student-led student team (with staff mentoring)
- To be launched in early 2003 (CubeSat Launch Company)



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CanX-1 General Arrangement

Separation Switch

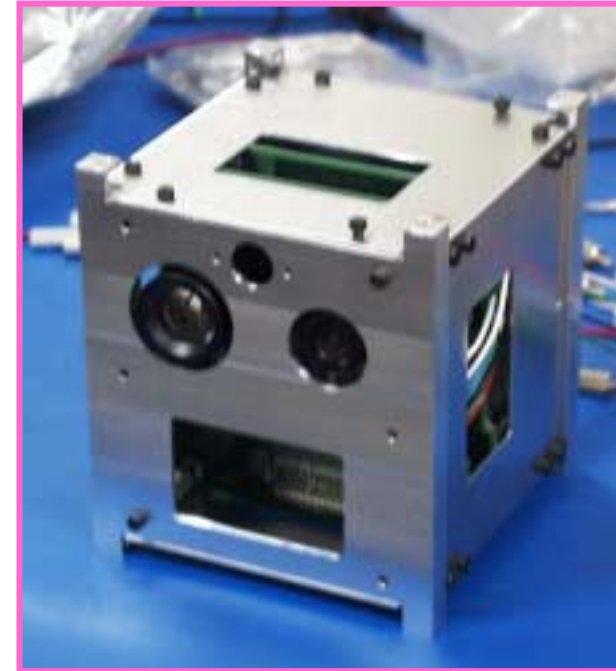
Circuit Board
Spacers

Battery Pack

Color Imager

B/W Imager

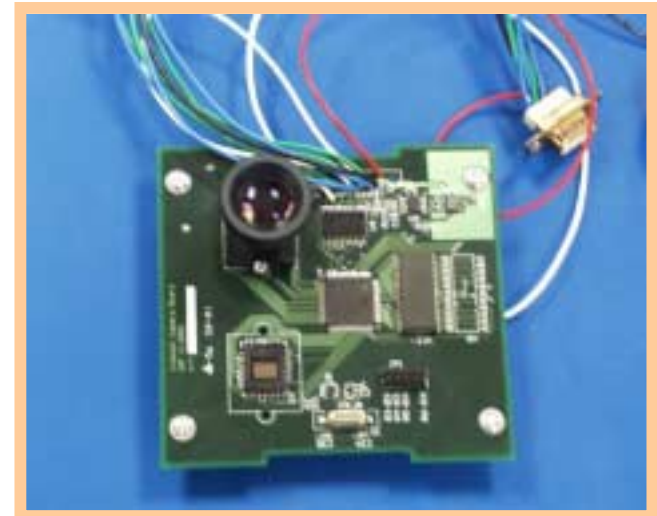
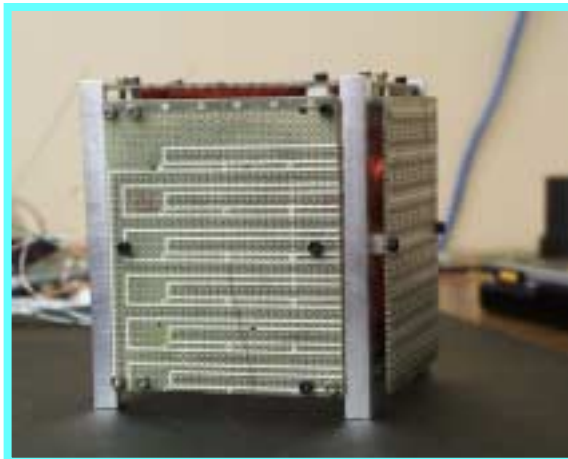
10 x 10 x 10 cm



Solar Cells

Custom CubeSat Components

- ARM7 Computer Board
- CMOS Imager Board
- Magnetorquers
- Power system, including Peak Power Tracker



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More Information

- Visit www.utias-sfl.net
- Contact Dr. Robert E. Zee at rzee@utias-sfl.net

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Low-Cost Spacecraft

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